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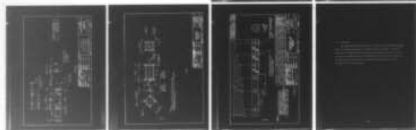
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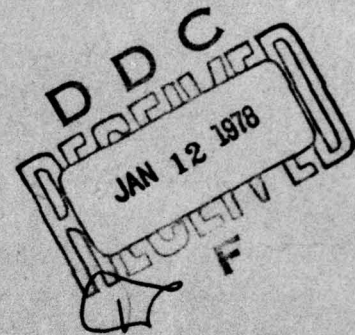
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TECHNIQUES AND MACHINING PROCESSES USED IN THE MANUFACTURE
OF COMPONENTS FOR HIGH ALTITUDE MASS SPECTROMETERS

Otto Molter

Wentworth Institute of Technology
550 Huntington Avenue
Boston, Massachusetts 02115



Scientific Report No. 1

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AIR FORCE GEOPHYSICS LABORATORY
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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) → Fabrication techniques described in this report reflect on time saving methods and improved machining for several components used in High Altitude Mass Spectrometers. | | |

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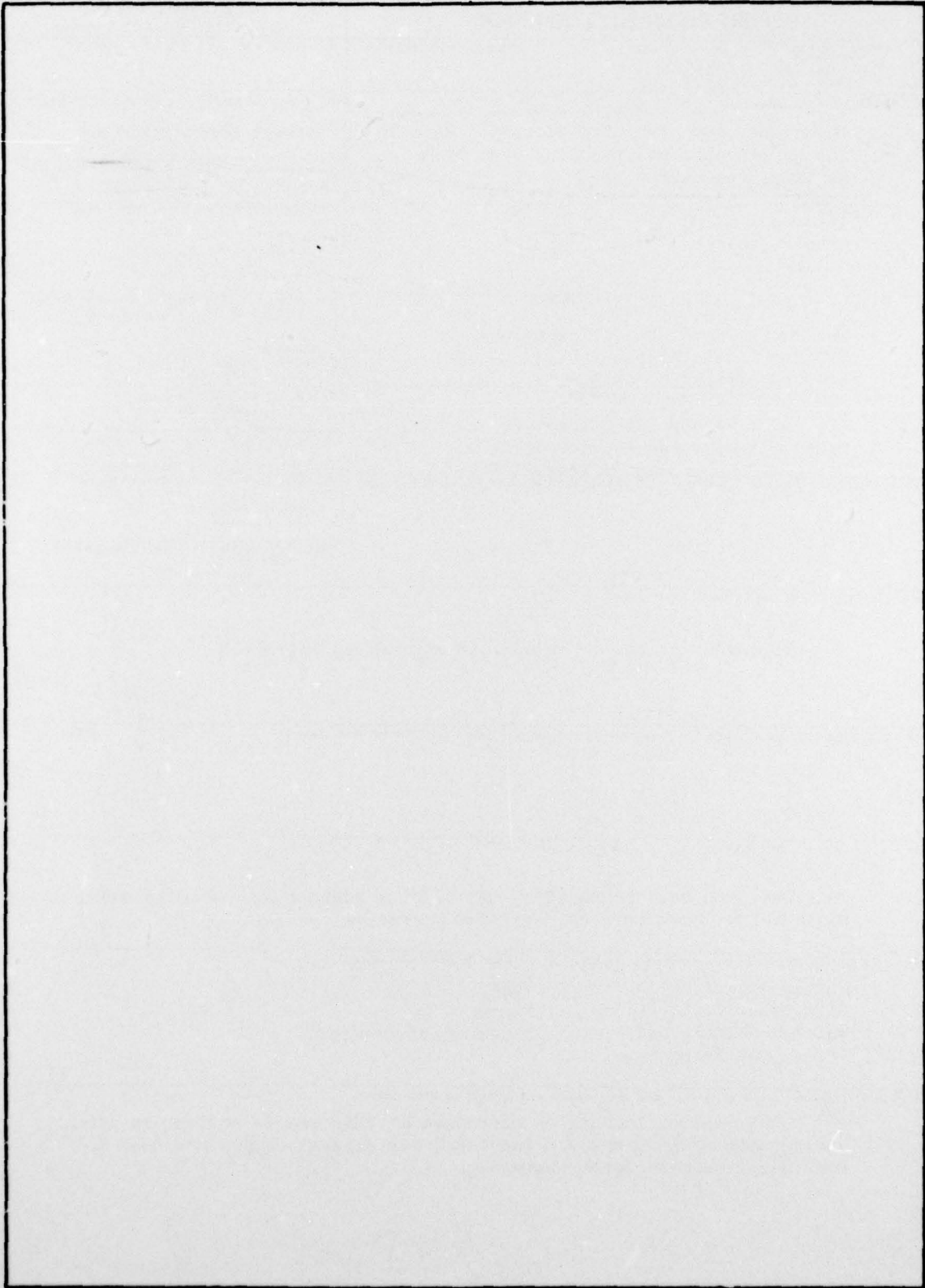
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LIST OF CONTRIBUTORS

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Amy Gaiennie, Secretary

Techniques and Machining Processes Used
in the Manufacture of Components
for High Altitude Mass Spectrometers

1.0 INTRODUCTION

Mass spectrometers have for some time been used to an increasing degree for the investigation of the upper atmosphere. These instruments, mounted in high altitude research rockets, must be capable of operating at very low pressures on the order of magnitude of 10^{-8} Torr or lower. They must be capable of surviving various vibrational shake tests without any impairment of their design function. This requires proper component design for structural integrity, and good machining procedures and methods regarding mating parts, parallelism, squareness and surface finishes.

2.0 DESCRIPTION

The first tasks emanated from design modifications requirements for a nitrogen and a helium pumped multiplier housing assembly units. New design and mechanical detail drawings were generated to incorporate a flange design that allowed the elimination of a welding operation.

2.1 Filament Holder Ion Source - LKD73-79B

These filament holders were manufactured from both 304 Stainless steel and commercially pure titanium.

Milling procedures used were the same for both materials. High speed steel tools were used, as they have the highest toughness and are more resistant to failure by chipping than carbide tools, particularly in the use of titanium. In the milling of titanium parts, it is absolutely essential to have sharp cutters, with the smallest diameter and largest number of teeth or flutes to minimize chatter and deflection. It was found advantageous to increase the relief angle over that used on a standard cutter by about 30%. This reduced the pressure and loading on the tool. It was found that high speed steel drills worked suitably well after the point was ground blunt to about a 140° angle. Water-soluble oil was used as a coolant for all machining.

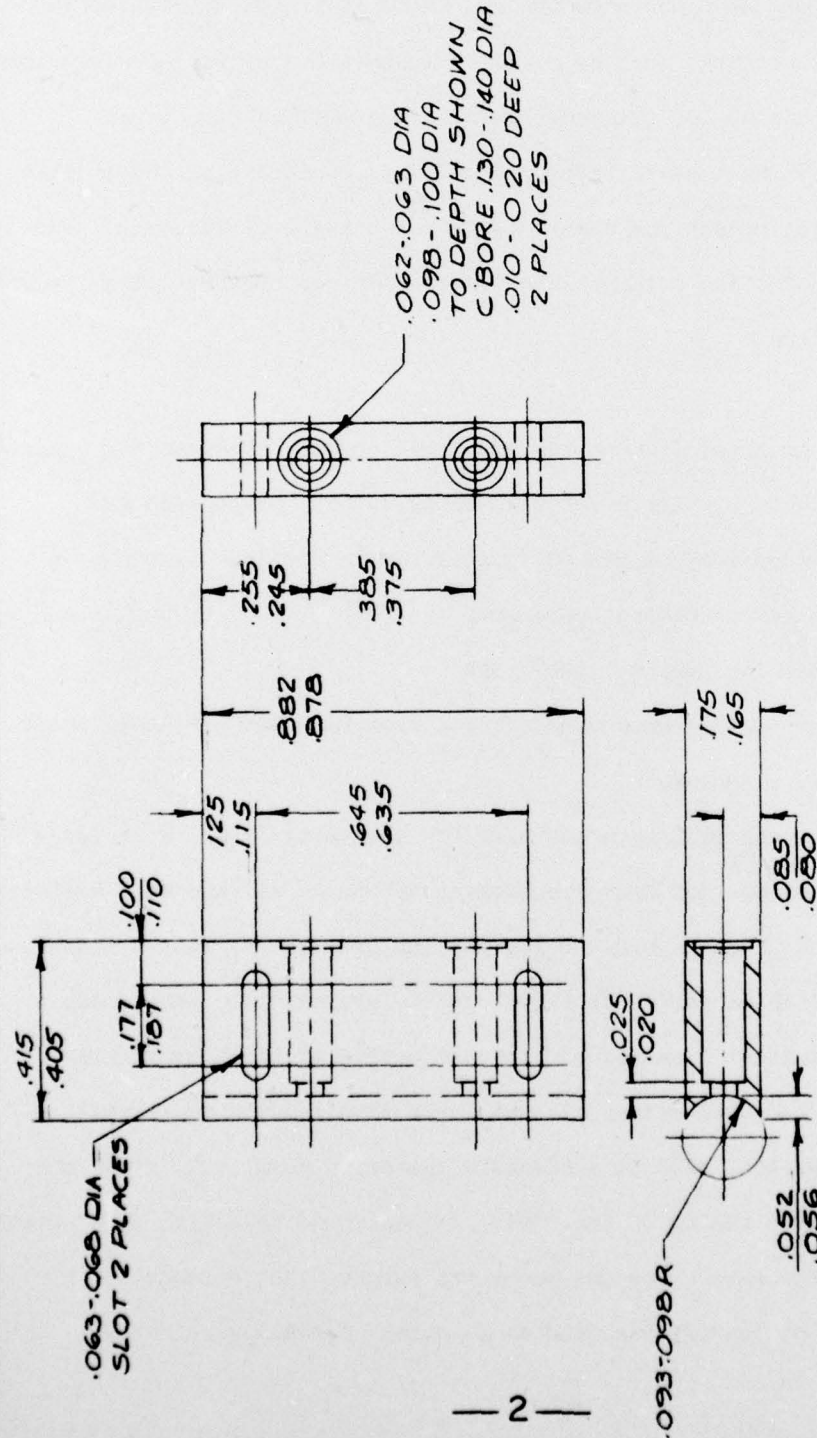


FIG 1

DRAWING REVISED AND REDRAWN 11-19-75

| | | | | | |
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| UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. | | DATE | 11/17/75 | AIR FORCE | |
| TOLERANCES UNLESS OTHERWISE SPECIFIED: | | DESIGNED BY | Dr. J. J. Donnell | CAMBRIDGE RESEARCH LAB | |
| FRACTIONS ± 1/16 | | CHECKED BY | | L. G. HANSCOM FIELD | |
| DECIMALS ± 0.005 | | APPROVED BY | | BEDFORD, MASS. | |
| ANGLES ± 30 | | DATE | | LKD73-79B | |
| MATERIAL | | SCALE | 4 X 1 | DRAWING NO. | |
| 304 SST | | | | | |
| TREATMENT | | | | | |
| FINISH | | | | | |
| 32/ | | | | | |

Regarding the elongated slots on the filament holders (Figure 1), in both the stainless steel and titanium pieces, a high speed steel end mill was originally used, but due to the tenacity of the materials, excessive wear and dulling of the cutting tool occurred.

An alternate method of machining slots proved more successful. An electric discharge machine with an electrode of brass and one of graphite was used. It was found the graphite electrode gave much faster cutting action.

2.2 Electrode Assembly (Switched Ion Neutral)

The electrode assembly is a component of the Ion Source Assembly, and is mounted on top of the housing of the switched ion neutral units. A cross section of this part is shown in Figure 2A.

The machining process required generating sloping surfaces on front and back sides with a resulting cross sectional thickness of .015. In order to achieve this cross section and maintain the required parallelism and straightness, much time was required.

Another method was devised that eliminated one machining operation and the problem of holding straight and parallel sides.

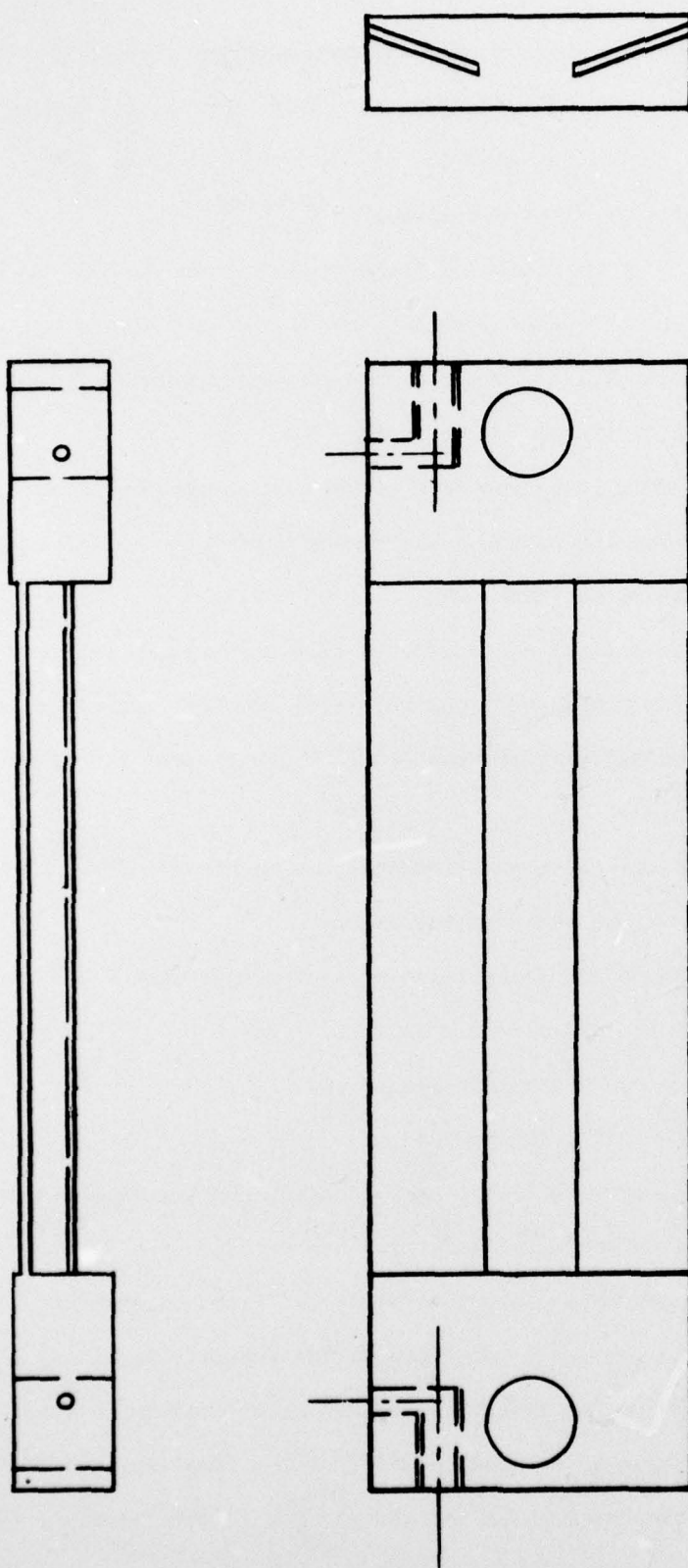
The back side was done with a ball end mill of proper size. The function of the part was unchanged by this method.

A cross-sectional view is shown in Figure 2B.

2.3 Filament Electrode - No. 1 Ion Source

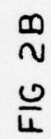
Manufacturing procedures were the same as described for filament holder ion source page 1, including the milling cutters and drills.

In the area of tapped holes in titanium, it was found to be more easily tapped, with galling, seizing and tap breakage reduced by cutting a 65% thread rather than the conventional 75%. It is also possible to improve the tapping procedure by grinding a heavy chamfer on the trailing edge of the tap, leaving a small portion of land on the cutting edge. This prevents rubbing between tap and work.



ELECTRODE ASSEMBLY

FIG. 2A



If the hole to be tapped shows a sign of burning or roughness, the possibility of breaking of the tap is high.

Non-sulfo-chlorinated oils or paste type cutting compounds may be used.

(For pictorial view of above described item, see Figure 3).

2.4 Quadrupole Housing (SW-I-N) LKD73-82C

Previous quadrupole housings were fabricated from three pieces, with flanges welded on each end of the housing body, requiring four operations:

1. Machine pieces oversize
2. Welding
3. Stress relieving
4. Final machining to desired dimensions

Due to alignment and close tolerances required with mating parts, control of the squareness, parallelism and concentricity was possible to a much higher degree of accuracy by eliminating operations 1, 2 and 3, and machining the quadrupole housing from one piece.

(For pictorial view of above described item, see Figure 4).

2.5 Quadrupole Rods

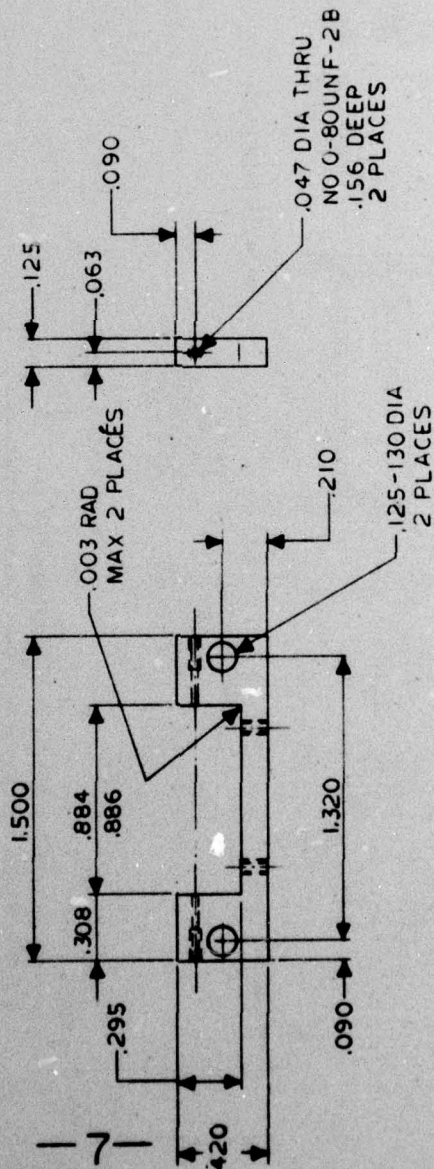
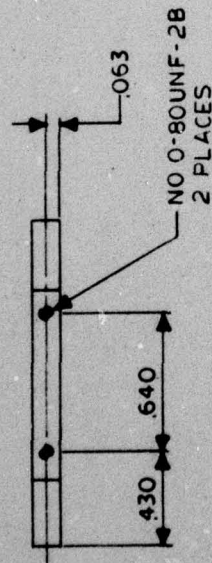
Originally 5/16 diameter 304 S.S. Rods were used and turned down to .255 diameter. They were then stress relieved to remove stresses introduced by turning operations. Holes were then drilled and tapped as required, and the rods were then centerless ground.

To reduce the time involved in making the rods, .253 diameter 304 S.S. rods were purchased, which is a standard item.

The pieces were then machined to desired length, drilled and tapped, and then centerless ground, thereby eliminating rough turning and grinding.

All quadrupole rods done by this method have proved satisfactory in all respects.

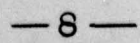
(For pictorial view of above parts, see Figure 5).



| PART NO | MATERIAL |
|---------|----------|
| -1 | 304 SST |
| -2 | TITANIUM |

FIG 3

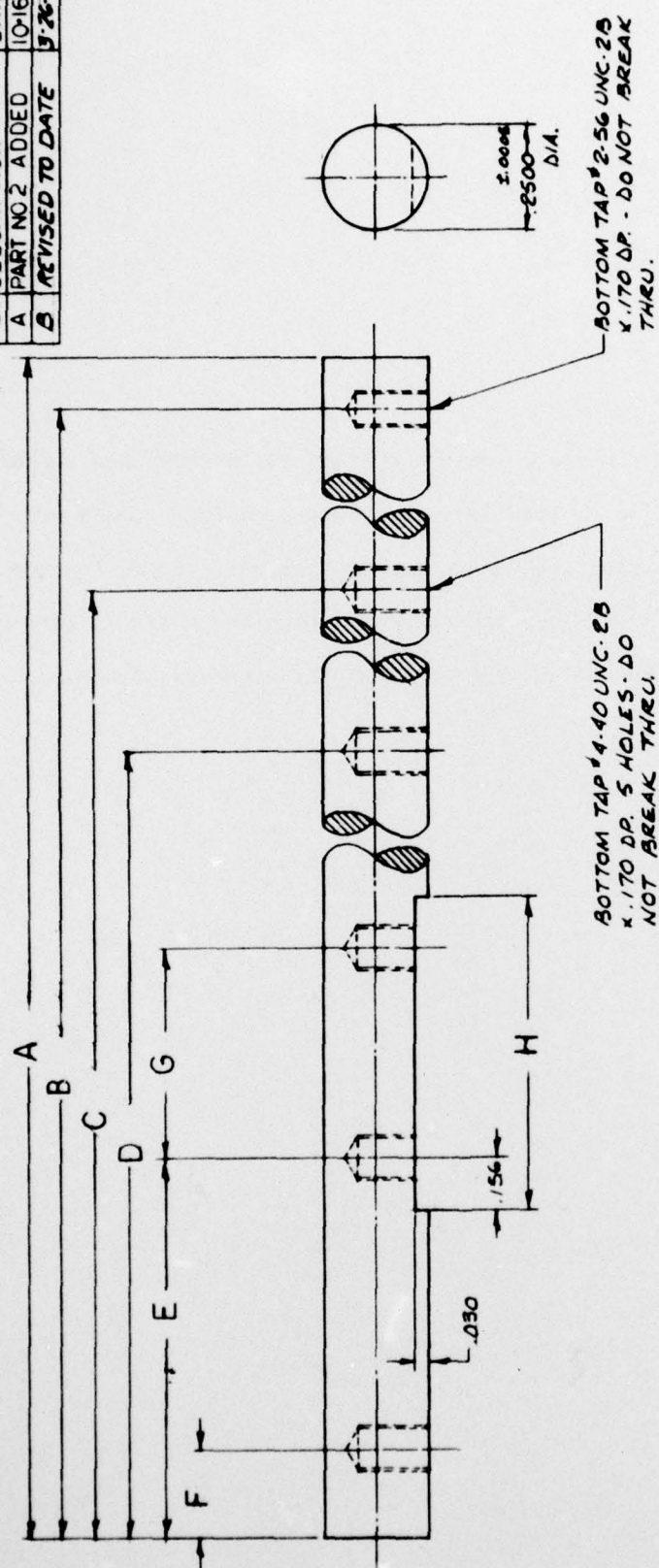
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| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES FRACTIONS DECIMALS ANGLES TOLERANCES ±.005 | | DATE 10-2-73 | SCALE 2 x 1 | WT. 57 |
| SEE CHART | | DATE 10-2-73 | FILAMENT ELECTRODE #1 ION SOURCE 5/8 FILAMENT | |
| TREATMENT | | DESIGNED BY m m s | DRAWN BY m m s | |
| FINISH 16/ F.A.O. | | CHECKED m m s | APPROVED m m s | |
| PART NO | | AIR FORCE CAMBRIDGE RESEARCH LAB L. S. HANCOCK FIELD BEDFORD, MASS. | | |
| PART NO | | LKD-73-80B | | |



1. REMOVE ALL BURRS AND BREAK SHARP EDGES .005 MAX
- 2 DIM REQUIRED OVER .250 LENGTH EACH END ONLY REMAINDER TO BE 1.250 - 1.260 DIA.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 1. NAME 2. GRADE 3. DATE 4. TIME 5. LOCATION 6. COMMENTS | 7. NAME 8. GRADE 9. DATE 10. TIME 11. LOCATION 12. COMMENTS | 13. NAME 14. GRADE 15. DATE 16. TIME 17. LOCATION 18. COMMENTS | 19. NAME 20. GRADE 21. DATE 22. TIME 23. LOCATION 24. COMMENTS | 25. NAME 26. GRADE 27. DATE 28. TIME 29. LOCATION 30. COMMENTS | 31. NAME 32. GRADE 33. DATE 34. TIME 35. LOCATION 36. COMMENTS | 37. NAME 38. GRADE 39. DATE 40. TIME 41. LOCATION 42. COMMENTS | 43. NAME 44. GRADE 45. DATE 46. TIME 47. LOCATION 48. COMMENTS | 49. NAME 50. GRADE 51. DATE 52. TIME 53. LOCATION 54. COMMENTS | 55. NAME 56. GRADE 57. DATE 58. TIME 59. LOCATION 60. COMMENTS | 61. NAME 62. GRADE 63. DATE 64. TIME 65. LOCATION 66. COMMENTS | 67. NAME 68. GRADE 69. DATE 70. TIME 71. LOCATION 72. COMMENTS | 73. NAME 74. GRADE 75. DATE 76. TIME 77. LOCATION 78. COMMENTS | 79. NAME 80. GRADE 81. DATE 82. TIME 83. LOCATION 84. COMMENTS | 85. NAME 86. GRADE 87. DATE 88. TIME 89. LOCATION 90. COMMENTS | 91. NAME 92. GRADE 93. DATE 94. TIME 95. LOCATION 96. COMMENTS | 97. NAME 98. GRADE 99. DATE 100. TIME 101. LOCATION 102. COMMENTS | 103. NAME 104. GRADE 105. DATE 106. TIME 107. LOCATION 108. COMMENTS | 109. NAME 110. GRADE 111. DATE 112. TIME 113. LOCATION 114. COMMENTS | 115. NAME 116. GRADE 117. DATE 118. TIME 119. LOCATION 120. COMMENTS | 121. NAME 122. GRADE 123. DATE 124. TIME 125. LOCATION 126. COMMENTS | 127. NAME 128. GRADE 129. DATE 130. TIME 131. LOCATION 132. COMMENTS | 133. NAME 134. GRADE 135. DATE 136. TIME 137. LOCATION 138. COMMENTS | 139. NAME 140. GRADE 141. DATE 142. TIME 143. LOCATION 144. COMMENTS | 145. NAME 146. GRADE 147. DATE 148. TIME 149. LOCATION 150. COMMENTS | 151. NAME 152. GRADE 153. DATE 154. TIME 155. LOCATION 156. COMMENTS | 157. NAME 158. GRADE 159. DATE 160. TIME 161. LOCATION 162. COMMENTS | 163. NAME 164. GRADE 165. DATE 166. TIME 167. LOCATION 168. COMMENTS | 169. NAME 170. GRADE 171. DATE 172. TIME 173. LOCATION 174. COMMENTS | 175. NAME 176. GRADE 177. DATE 178. TIME 179. LOCATION 180. COMMENTS | 181. NAME 182. GRADE 183. DATE 184. TIME 185. LOCATION 186. COMMENTS | 187. NAME 188. GRADE 189. DATE 190. TIME 191. LOCATION 192. COMMENTS | 193. NAME 194. GRADE 195. DATE 196. TIME 197. LOCATION 198. COMMENTS | 199. NAME 200. GRADE 201. DATE 202. TIME 203. LOCATION 204. COMMENTS | 205. NAME 206. GRADE 207. DATE 208. TIME 209. LOCATION 210. COMMENTS | 211. NAME 212. GRADE 213. DATE 214. TIME 215. LOCATION 216. COMMENTS | 217. NAME 218. GRADE 219. DATE 220. TIME 221. LOCATION 222. COMMENTS | 223. NAME 224. GRADE 225. DATE 226. TIME 227. LOCATION 228. COMMENTS | 229. NAME 230. GRADE 231. DATE 232. TIME 233. LOCATION 234. COMMENTS | 235. NAME 236. GRADE 237. DATE 238. TIME 239. LOCATION 240. COMMENTS | 241. NAME 242. GRADE 243. DATE 244. TIME 245. LOCATION 246. COMMENTS | 247. NAME 248. GRADE 249. DATE 250. TIME 251. LOCATION 252. COMMENTS | 253. NAME 254. GRADE 255. DATE 256. TIME 257. LOCATION 258. COMMENTS | 259. NAME 260. GRADE 261. DATE 262. TIME 263. LOCATION 264. COMMENTS | 265. NAME 266. GRADE 267. DATE 268. TIME 269. LOCATION 270. COMMENTS | 271. NAME 272. GRADE 273. DATE 274. TIME 275. LOCATION 276. COMMENTS | 277. NAME 278. GRADE 279. DATE 280. TIME 281. LOCATION 282. COMMENTS | 283. NAME 284. GRADE 285. DATE 286. TIME 287. LOCATION 288. COMMENTS | 289. NAME 290. GRADE 291. DATE 292. TIME 293. LOCATION 294. COMMENTS | 295. NAME 296. GRADE 297. DATE 298. TIME 299. LOCATION 300. COMMENTS | 301. NAME 302. GRADE 303. DATE 304. TIME 305. LOCATION 306. COMMENTS | 307. NAME 308. GRADE 309. DATE 310. TIME 311. LOCATION 312. COMMENTS | 313. NAME 314. GRADE 315. DATE 316. TIME 317. LOCATION 318. COMMENTS | 319. NAME 320. GRADE 321. DATE 322. TIME 323. LOCATION 324. COMMENTS | 325. NAME 326. GRADE 327. DATE 328. TIME 329. LOCATION 330. COMMENTS | 331. NAME 332. GRADE 333. DATE 334. TIME 335. LOCATION 336. COMMENTS | 337. NAME 338. GRADE 339. DATE 340. TIME 341. LOCATION 342. COMMENTS | 343. NAME 344. GRADE 345. DATE 346. TIME 347. LOCATION 348. COMMENTS | 349. NAME 350. GRADE 351. DATE 352. TIME 353. LOCATION 354. COMMENTS | 355. NAME 356. GRADE 357. DATE 358. TIME 359. LOCATION 360. COMMENTS | 361. NAME 362. GRADE 363. DATE 364. TIME 365. LOCATION 366. COMMENTS | 367. NAME 368. GRADE 369. DATE 370. TIME 371. LOCATION 372. COMMENTS | 373. NAME 374. GRADE 375. DATE 376. TIME |
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| REV | DESCRIPTION | DATE |
|-----|-----------------|----------|
| A | PART NO.2 ADDED | 10-16-73 |
| B | REVISED TO DATE | 9-26-73 |



- NOTES:
1. TH'D. HOLES ARE TO BE MADE PRIOR CENTERLESS GRINDING.
 2. STRESS RELIEVE AT 675°F. FOR 2 HOURS, SUPPORTED AT ONE END ONLY BEFORE GRINDING.
 3. FINISHED ROD TO BE STRAIGHT END TO END WITHIN .001 T.I.R.
 4. TH'D. HOLES TO BE COPLANAR.

| PART NO | A ±.001 | B ±.001 | C ±.001 | D ±.001 | E ±.020 | F ±.001 | G ±.020 | H ±.005 |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| -1(RCA MULTIPLIER) | 9815 | 9.690 | 6.970 | 3.590 | .860 | .210 | .500 | .873 |
| -2(JL MULTIPLIER) | 11.383 | 11.258 | 8.538 | 5.158 | 2.428 | 1.778 | .500 | .873 |
| -3(JL MULTIPLIER) | 11.383 | 11.258 | 8.538 | 5.158 | 2.428 | 1.778 | 1.250 | 1.563 |
| -4(RCA MULTIPLIER) | 9815 | 9.690 | 6.970 | 3.590 | .860 | .210 | 1.250 | 1.563 |

| | |
|---|--|
| QUADRUPOLE ROD HELIUM INST. GONIS | AIR FORCE CAMBRIDGE RESEARCH LAB L. S. HANCOCK FIELD BEDFORD, MASS. |
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|----------------------|----------------------------|
| SCALE 4" = 1" ST. | LHD 73-75-B DRAWING NO. |
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- FIG. 5 -

3.0 CONCLUSION

The above report describes some of the operations, methods and techniques used in the machine processing of stainless steel and titanium. Costs were significantly reduced by eliminating unnecessary operations, and by the use of the electric discharge machine in generating small holes and slots in less time and eliminating the use of end mills where dulling and breakage of these resulted, due to their small size.